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SOCIAL NETWORK ANALYSIS WITHIN THE ICMB COMMUNITY: CO-AUTHORSHIP NETWORKS

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Abstract

Founded in Athens during 2002, ICMB developed to the major international research conference on mobile business with a significant number of researchers and authors contributing state of the art scientific papers in academia. In this paper we examine the state of the ICMB co-authorship network from 2002 to 2013 by applying Social Network Analysis techniques and measures. Our analysis is based on a network model generated by data gathered from papers featured in the aforementioned conferences. Our analysis consists of metrics such as clustering analysis, degree, betweenness centrality measures as well as network component related properties. These measures aim to answer a wide range of questions about collaboration patterns, such as the numbers of papers submitted, co-authorships, and showcase how patterns of collaboration emerge between larger scale, tightly connected node formations of the co-authorship network.

Keywords: *Social Networks Analysis, ICMB, Co-authorship network*

1 Introduction

Mobile business changed a lot in the last twelve years, rising from a niche topic - all the way along the Gartner hype cycle - to one of the most relevant issues for many of today's businesses and researchers. Mobility changes users' daily lives in its private as well as in its professional part. Mobile business created own ecosystems, constantly changes them and even begins to change existing ecosystems in the real world, redistributing market power in consumer-oriented industries and revolutionizing business processes in all industries that include mobility aspects or mobile workers. In the future, we will see mobility as the invisible norm [1]. These words taken from an abstract of ICMB's 2013 Conference material posted on the web, identify the importance of Mobile Business and stress the need for continuous research on the field. Picking up from 2013, ICMB 2014 which will be held in London from June 4 to June 5 2014 aims at continuing ICMB's mission on the exploration and debate of new business models and services that leverage mobile and ubiquitous computing technologies.

ICMB Conferences have induced a pattern of co-authorship collaborations between participants which have shaped the domain of mobile business in both academic and managerial sectors over the past decade. Our goal in this paper is to get an in depth view of these collaborations, by applying social networks analysis techniques, in order to attain deeper knowledge on the specific community and its works.

To perform this analysis we gathered all published articles from the proceedings of the conferences. Three undergraduate students coded the data that was essential for analysis such as authors, titles, year, etc. in .csv format. Data was then imported to an SQL Database for preliminary analysis to be performed. The team used Gephi for visualization based analysis and MatLab for statistical analysis presenting findings in graph, chart and table formats.

2 Background

2.1 ICMB

Founded in 2002 in Athens, ICMB developed to the major international research conference on mobility and mobile business to date. ICMB has been held annually since 2002, each year in a different region of the world. Prior locations include Athens, Greece (2002), Vienna, Austria (2003), New York, USA (2004), Sydney, Australia (2005), Copenhagen, Denmark (2006), Toronto, Canada (2007), Barcelona, Spain (2008), Dalian, China (2009), Athens, Greece (2010), Como, Italy(2011), Delft, Netherlands(2012), Berlin, Germany(2013) and London, UK(2014). More than 600 papers have been shared in the proceedings from more than 1000 authors around the world.

2.2 Social Network Analysis

Social Network Analysis is a field of research that has been studied from the start of the 20th century by social scientists and recently has attracted interest, especially with the rapid rise and proliferation of online social networks, in disciplines such as information systems, economics and computer science

[2, 3, 4, 5 and 10]. Popular examples of network analysis findings are Milgram's small world problem also known as "Six Degrees of Separation" experiment [6, 7], The Erdős number [8] and the Kevin Bacon game [9]. These examples have become cornerstones in using network analysis to discover relationships within networks and since then, network science has evolved providing mature metrics that reveal associations between network members.

The basic notion behind networks or graphs is that they consist of collections of points joined by lines revealing patterns of interconnections among a set of things [4]. Nodes typically represent actors whilst edges reveal a form of relationship between two actors. This representation allows researchers to apply graph theory allowing them to solve problems which otherwise would require complex mathematical processing [11]. When people interact, they share knowledge, change knowledge, create knowledge, etc. Studying and modeling networks allows us to discover what knowledge there is, who has it and how it was generated. As soon as the graph has been established, Graph Theory and Social network Analysis allows us to define characteristics of the actors and characteristics of the relationships. Properties such as the diameter, clustering, giant component and small worlds provide information about the network as a whole, revealing information about the relationships between the actors in the network. On the other hand properties such as centrality measures, degree and clustering coefficients reveal information about the individual in the network.

2.3 Co-authorship Networks

Co-authorship networks hold a substantial place in social network analysis and have been studied since the 1960's in an attempt to examine scientific collaborations at an interdisciplinary and international level [12, 13 and 14]. Incentives to do so are due to a number of reasons we briefly present below. Early research in co-authorship networks aimed at analyzing the financial support required for forming teams [14]. Sub-Authorship is another sector which analysis of co-authorship networks aimed at studying. In 2002, Laudel showed that a major part of collaboration is not acknowledged either through a proper acknowledgement or through co-authorship. Another interesting finding is that published in 1994 by Kretschmer who analyzed aspects of social stratification in scientific collaboration at the micro level with the main findings revealing extramural collaboration characterized by similarity of the social status in contrast to intramural collaboration showing significant differences of the social status of the co-authors [16]. Newman has studied co-authorship networks revealing small networks topology while Barabasi also pointed out the short path that connects authors in scientific research [17, 18]. Finally Glanzel and Schubert analyzed co-authorship networks revealing cross-national collaboration at both author and country level [19].

3 Constructing Co-authorship Networks

3.1 Weighted, directed co-authorship networks

In this section, we lay the fundamental representational framework that we have utilized to construct the underlying co-authorship network for the ICMB conference. Our formulation builds upon the general mathematical model of a directed – symmetrical weighted graph $G = (V, E, W)$ where $V = \{v_1, \dots, v_n\}$ is the set of nodes corresponding to the set of unique authors, $E \subset V^2$ is the set of edges between nodes and $W \in M_{n \times n}$ is the associated weight matrix whose w_{ij} element stores the connection strength between the ordered set of authors (v_i, v_j). Since the adopted representational model is a symmetric one, $w_{ij} = w_{ji}, \forall i, j \in [n]\ for\ i \neq j$ where the $w_{ii}\ for\ i\ \in [n]$ weight elements correspond to the total number of publications for the $i - th$ node. The connection strength w_{ij} for each edge $e = (v_i, v_j) \in E$ can be quantified by initially considering the complete set of publications $P = \{p_1, \dots, p_m\}$ and by subsequently defining the function mapping $f: P \rightarrow \wp(V)$, where $\wp(V)$ is the powerset of V, such that $f(p)$ returns the set of authors (nodes) participating in article p. In this context, the elements of the weight matrix W can be determined through the utilization of the following equation:

$$w_{ij} = \left|\{p \in P: w_i \in f(p) \wedge w_j \in f(p)\}\right| \quad (1)$$

assigning a weight value to each pair of authors $(v_i, v_j)\ i, j \in [n]$ which is equal to the number of their common publications. The functional mapping f can also be utilized for the determination of the set of edges $E$by employing the following equation:

$$E = \{(v_i, v_j) \in V^2: \exists p \in P, v_i \in f(p) \wedge v_j \in f(p)\} \quad (2)$$

Some of the co-authorship network analysis metrics that are utilized in this paper, including degree centrality, closeness centrality, betweenness centrality and the extraction of the connected network components, require a binary weighting scheme for the edges. Such a weighing scheme can be easily obtained by extending the original one described in Eq.1 through the utilization of the following equation:

$$w'_{ij} = \begin{cases} 1, if w_{ij} > 0; \\ 0, otherwise. \end{cases} \quad (3)$$

3.2 Metrics for co-authorship networks

This section summarizes the set of social network metrics that were employed to analyse the co-authorship network for the ICMB conference, including component, centrality and cluster analysis related measures [4], as well as the application of the AuthorRank modification of the original PageRank algorithm proposed by Liu et al. in [20]. These metrics measure various structural network properties, aiming at revealing significant information concerning the most important nodes, components and communities of the scientific collaboration graph that otherwise cannot be detected.

Component analysis, for instance, focuses on determining the subsets of network nodes for which there is a path between any given pair of nodes and thereby are characterised as connected components. The identification of the connected components for a co-authorship network is extremely critical since such networks are usually highly fractioned, formed by many disconnected components. Groups of nodes with significant importance can also be identified by performing community detection. In this paper, community detection was performed on the basis of the modularity minimization principle [4], aiming at grouping together nodes exhibiting a higher amount of ties with members within a particular set of nodes than with the rest of the network. In this context, community detection was conducted to reveal the tightest components within the co-authorship network of ICMB.

Another aspect of analysis is focused on extracting a set of centrality-related metrics, namely the degree centrality, closeness centrality and betweenness centrality. Degree centrality refers to the total amount of edges that are adjacent to a particular node, representing the simplest instantiation of the centrality notion since it measures only how many connections tie a given author to its immediate neighbourhood within the network. Closeness centrality, on the contrary, expands the original definition of the degree centrality by focusing on how close an author is to all the other authors. The closeness centrality measure can be calculated by determining a node's shortest-path distances to all other nodes in the network and by subsequently inverting these values to form a metric of closeness. This measure aims at distinguishing situations where an author may be well connected to its immediate neighbours but be part of a relatively isolated clique. Another important feature of the closeness centrality measure is that it can only be computed on a connected network. Therefore, since the ICMB co-authorship network is not a connected one, the closeness centrality values that are presented for a particular node are computed by considering the corresponding connected network component containing that node. Finally, betweenness centrality can be thought of as a different realization of centrality based on measuring the frequency of founding a given node on the shortest path between any pair of nodes in the network. In this sense, nodes that are often on the shortest path between other nodes are deemed to be highly central because they control the information flow within the network.

The AuthorRank is an alternative ranking mechanism initially proposed by Liu et al. in [11] to measure the prestige of a particular node by modelling inherited or transferred status, exploiting the adopted weighting scheme given by Eq.1. The AuthorRank metric is based on the original PageRank measure associated with the well-established notion of eigenvector centrality. PageRank can be easily calculated by employing a simple iterative algorithm, corresponding to the principal eigenvector of the normalized weight matrix which characterizes the co-authorship network graph.

4 ICMB Research Community Co-authorship Analysis

4.1 Overall Co-authorship Network Statistics

We collected and analysed the ICMB-related publication data for the period of the last twelve years between 2002 and 2013 by archiving information concerning the authors, title, year and abstract of each article, resulting in a dataset which contains a number of 1155 authors and 643 publications. This paper, however, focuses exclusively on the structural information that can be extracted from the corresponding co-authorship graph which is built upon the first three of the aforementioned factors. Figure 1 presents the time evolution of the volume of publications over the years, having as an overall maximum a number of 110 publications in 2005, on the ICMB conference that was held in Australia.

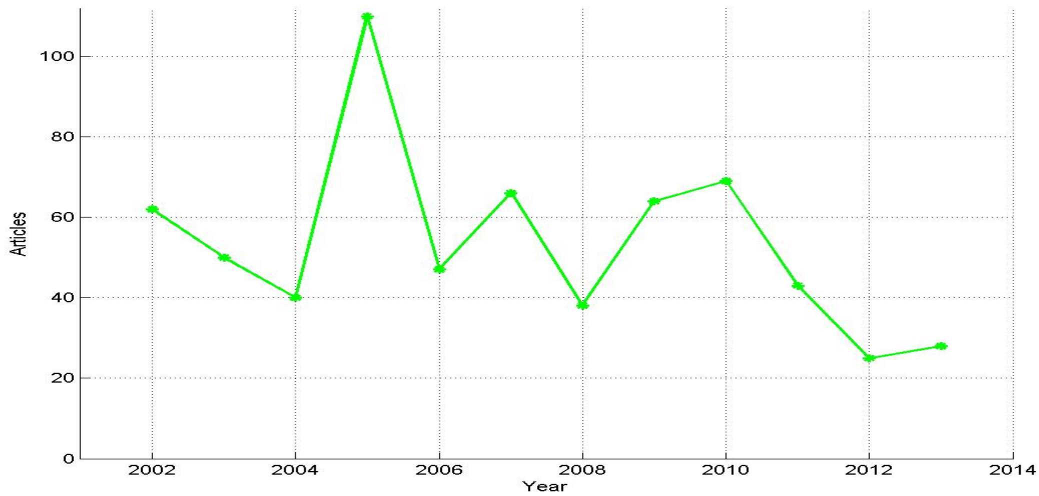

Figure 1. Volume of publications per year.

Additional information concerning the authors' participation within the ICMB conference can be found in Figure 2, which jointly presents the time evolution of the number of authors and the number of the new authors over the years. It is not surprising that both graphs exhibit an overall maximum at the fourth point of the time axis, corresponding to the 2005 ICMB conference held in Australia with 243 authors in total and 212 of them participating in the conference for the first time. The authors per publication distribution appears in Figure 3, indicating that the most common pattern of publication within the ICMB conference concerns pairs of authors for an amount of 223 (or 34.68%) publications.

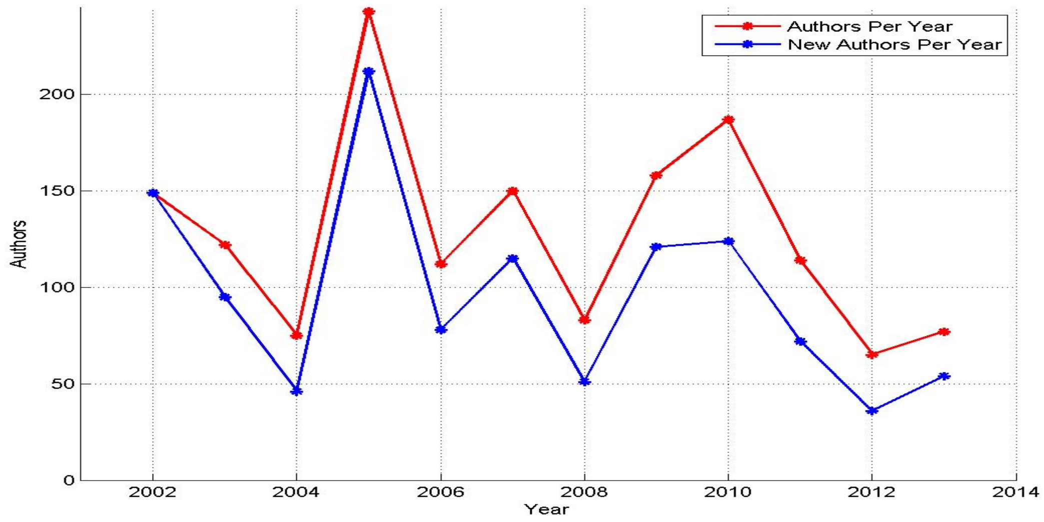

Figure 2. Volume of authors and new authors per year.

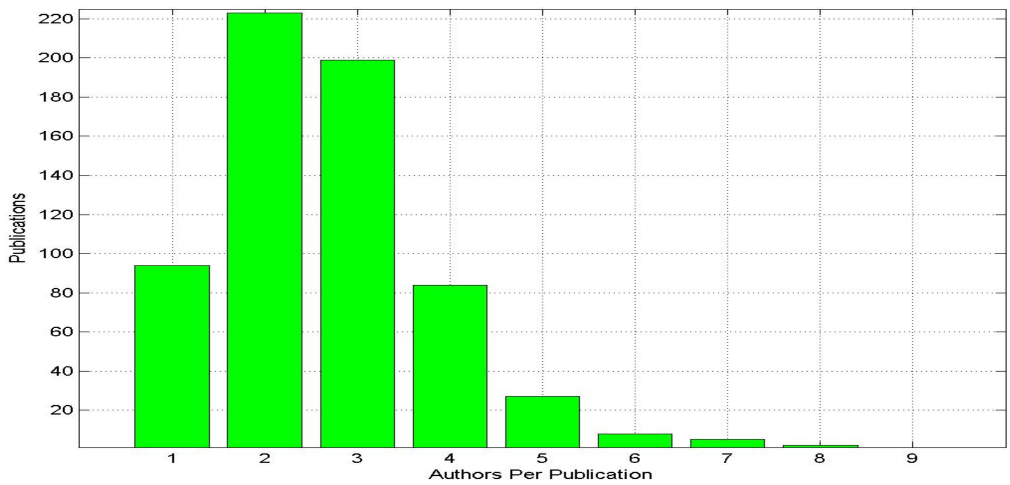

Figure 3. Authors per publication distribution.

Figure 4 presents the complementary publications per author distribution indicating that the vast majority of participants (880 or 76.19%) within the ICMB conference published for a single time and then never published again. This result is in total accordance with the curve of the new authors per year in Figure 2, indicating that the volume of publications per year that are submitted by new authors is a significant portion of the total amount of authors for every year. There is only a small group of 14 authors that have published at least 8 papers throughout the 12 years of the ICMB conference which are presented in Table 1.

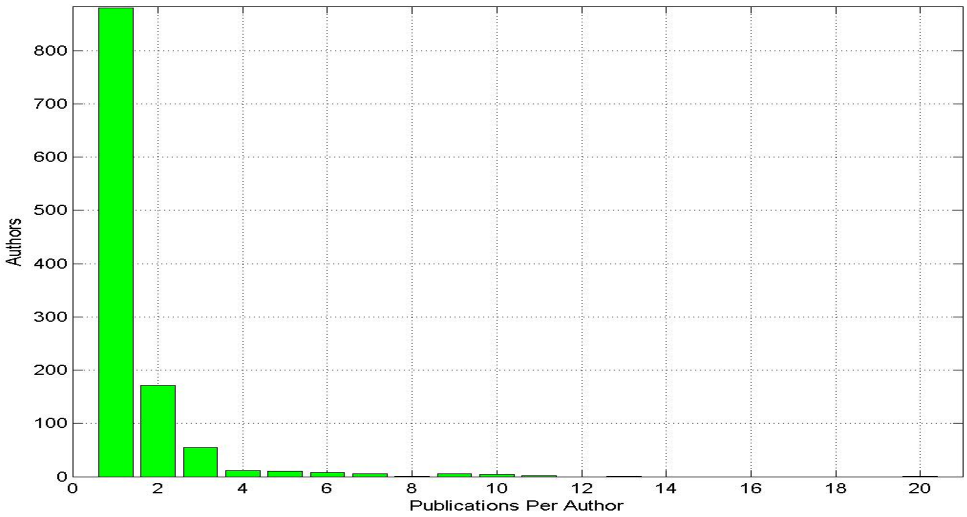

Figure 4. Publications per author distribution.

The most active authors of the ICMB community appear on the top five rows of Table 1 which are namely Arkady Zaslavsky with 10 publications, Toshihiko Yamakami and Eusebio Scornavacca with 11 publications, Key Pousttchi with 13 publications and on the top of the list Geoge Giaglis with 20 publications.

Rank	Author	Publications Volume
1	George M Giaglis	20
2	Key Pousttchi	13
3	Eusebio Scornavacca	11
4	Toshihiko Yamakami	11
5	Arkady Zaslavsky	10
6	Andrea Rangone	10
7	Filippo Maria Renga	10
8	Katina Michael	10
9	Giovanni Camponovo	9
10	L. Pau	9
11	Elaine Lawrence	9
12	Harry Bouwman	9
13	Antonio Ghezzi	9
14	Christos K. Georgiadis	8

Table 1. Authors that published at least 8 articles.

4.2 Co-authorship Network Communities and Components

Community detection for the co-authorship network of the ICMB conference was performed on the basis of the modularity minimization principle operating on the weight matrix of the graph given by

Equation 1. The obtained clustering results and the corresponding co-authorship network organization into strongly tight groups of nodes are presented in Figure 6 where each community is denoted with a different colour. The top 10 largest communities that were extracted are summarized in Table 2 according to which the largest commmunity contains 45 nodes and it is identified by the name Xiangpei Hu which is its highest degree node. Harry Bouwman is the highest degree node of the second largest community with 41 nodes while Filippo Maria Renga is the highest degree author of the third largest community with 33 nodes. The list of communities containing a number of over 30 nodes is completed by mentioning the fourth largest community which is identified by the name of its highest degree node, Junichi Iijima.

The cross examination of the community detection results along with the information extracted from the component analysis, summarized in Table 3, can provide significant insight in inferring the collaboration patterns of authors that participated in the ICMB conference. Table 3, in particular, presents the top10 largest components of the co-authorship network, identified by the names of their highest degree nodes. Xiangpei Hu and Harry Bouwman appear on the first two positions of the largest components list containing 97 and 55 nodes respectively, indicating that they constitute representatives of larger scale node formations than their corresponding communities. The same situation may be encountered for the third largest co-authorship network component with 44 nodes, represented by George Giaglis, which is at the same time the highest degree author of the sixth largest network community with 27 nodes. However, this is not the case for the fourth largest network component, represented by Filippo Maria Renga with 33 nodes since this group of nodes coincides with third largest network community.

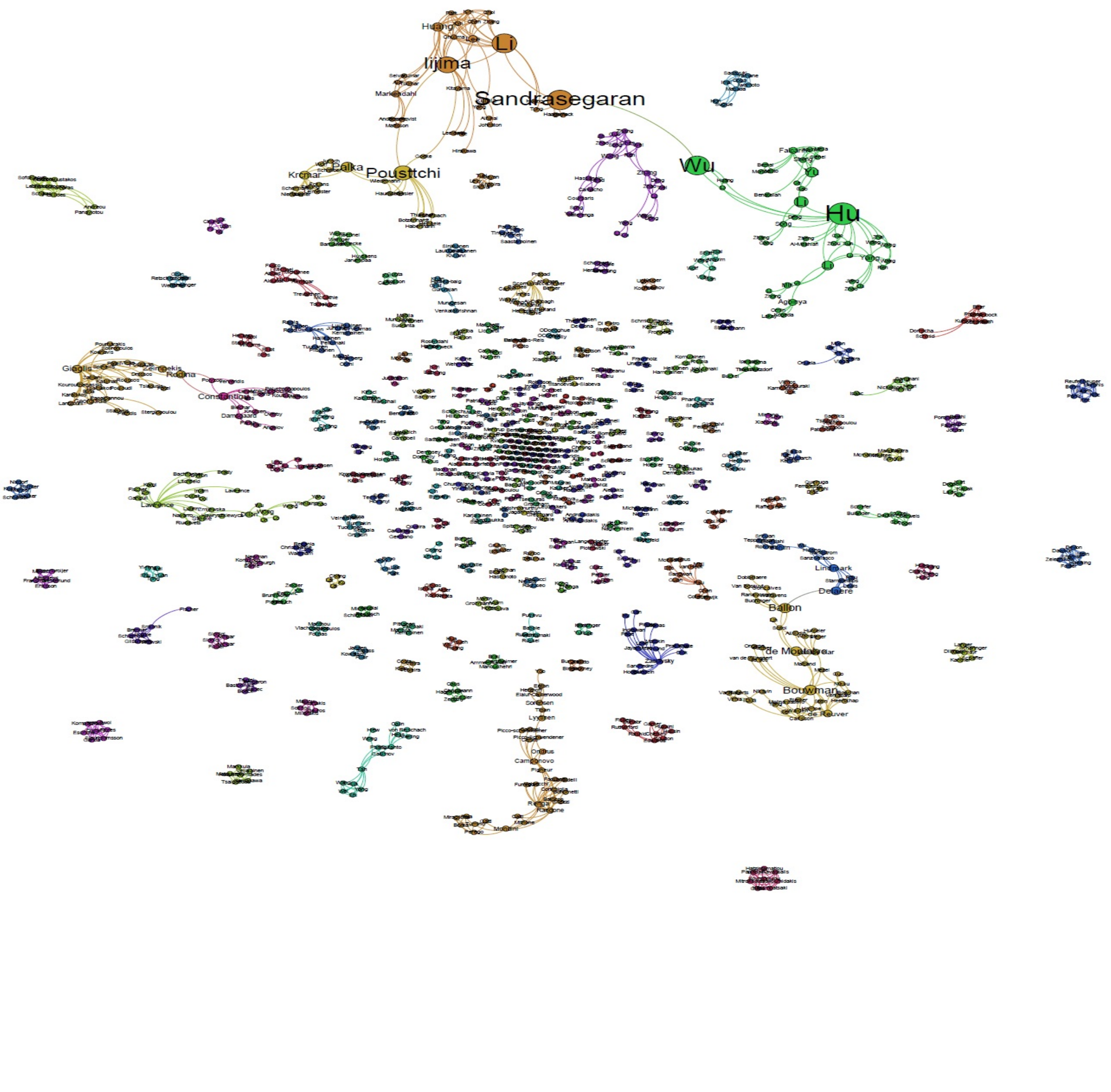

Figure 6. ICMB communities.

Rank	Maximum Degree Node	Nodes
1	Xiangpei Hu	45
2	Harry Bouwman	41
3	Filippo Maria Renga	33
4	Junichi Iijima	31
5	Elaine Lawrence	28
6	George M Giaglis	27
7	Jinlong Zhang	26
8	Key Pousttchi	21
9	Ioanna D. Constantiou	17
10	Arkady Zaslavsky	17

Table 2. Top 10 co-authorship network communities.

Rank	Maximum Degree Node	Nodes
1	Xiangpei Hu	97
2	Harry Bouwman	55
3	George M Giaglis	44
4	Filippo Maria Renga	33
5	Elaine Lawrence	28
6	Guoqing Chen	26
7	Arkady Zaslavsky	17
8	Eusebio Scornavacca	15
9	Virpi Kristiina Tuunainen	15
10	Chor Min Tan	15

Table 3. Top 10 co-authorship network components.

4.3 Centrality Metrics and AuthorRank

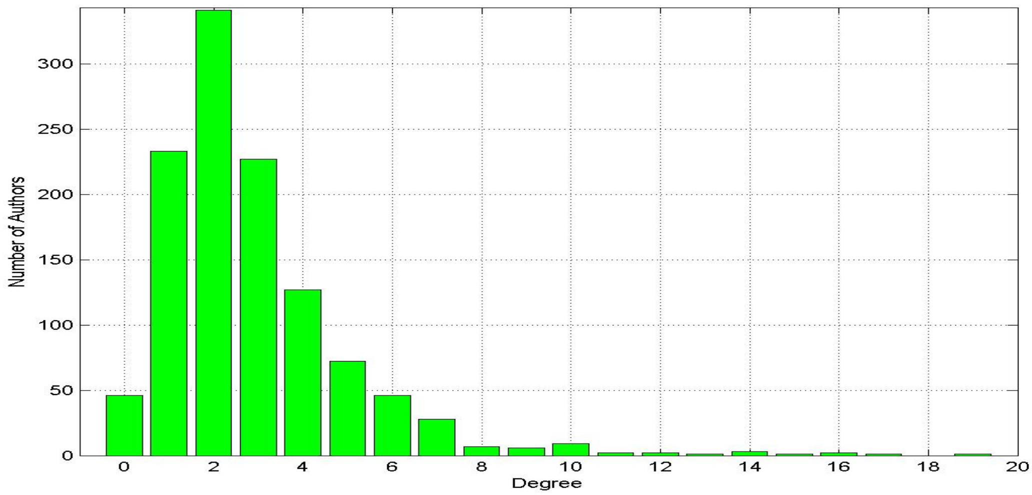

Figure 5. Node degrees distribution.

The degree centrality distribution is shown in Figure 5, following a rough power-law distribution with a few authors having a high connection degree, and most authors having a low degree. Table 4 presents the top 10 authors ranked by their corresponding degree centrality values along with their associated betweenness centrality and closeness centrality values. The five authors appearing on the top of the list in descending order are George M Giaglis (19), Xiangpei Hu (17), Arkady Zaslavsky (16), Elaine Lawrence (16) and Harry Bouwman (15). These authors happen to be the highest degree representatives of their corresponding network components and communities.

Rank	Author	Degree	Betweenness	Closeness
1	George M Giaglis	19	0.000667	0.014974
2	Xiangpei Hu	17	0.004149	0.021761
3	Arkady Zaslavsky	16	0.000165	0.013865
4	Elaine Lawrence	16	0.000351	0.011919
5	Harry Bouwman	15	0.001227	0.017427
6	Filippo Maria Renga	14	0.000344	0.012498
7	Junichi Iijima	14	0.002941	0.021183
8	Jinghua Huang	14	0.000958	0.020321
9	Mo Li	13	0.003480	0.022818
10	Andrea Rangone	12	0.000175	0.012155

Table4. Top 10 authors in degree centrality.

Table 5 presents the 10 highest AuthorRank scoring authors with their corresponding values. The top 5 most prestigious authors according to the AuthorRank metric in descending order are George M Giaglis, Arkady Zaslavsky, Elaine Lawrence, Eusebio Scornavacca and Xiangpei Hu which once again happen to be the highest degree representatives of their corresponding connected components and communities.

Rank	Author	AuthorRank
1	George M Giaglis	0.004913
2	Arkady Zaslavsky	0.004413
3	Elaine Lawrence	0.004067
4	Eusebio Scornavacca	0.003756
5	Xiangpei Hu	0.003497
6	Harry Bouwman	0.003352
7	Key Pousttchi	0.003318
8	L. Pau	0.003277
9	Katina Michael	0.003111
10	Virpi Kristiina Tuunainen	0.002752

Table 5. Top 10 authors according to author rank.

5 Discussion

In this paper we have analyzed and presented findings on the co-authorship network of the ICMB Community from 2002 to 2013. Results depict the significant contribution the particular community has made in the field of Mobile Business through the last decade. Results show how the community evolved and matured through time, providing high quality scientific research papers to academia while at the same time forming clusters of collaboration within its members through co-authoring. Results presented in this paper represent only a small fraction of the analysis that can be performed with this set of data and primarily acts as a small example of key metrics for presentation within the ICMB community for conference purposes. Future directions of study include application of machine learning algorithms which predict ties in the co-authorship network both in terms of topics and fields of application.

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